MICROPALAEONTOLOGICAL STUDIES OF THE UPPER JURASSIC AND LOWER CRETACEOUS OF ANDØYA, NORTHERN NORWAY

by MAGNE LØFALDLI *and* BINDRA THUSU

ABSTRACT. Seventy species of foraminifera are recognized and grouped into three assemblages. Assemblage 1, entirely dominated by *Haplophragmoides* represents a restricted, marginal marine environment and is confined to the lower part of Ratjønna Member of the Middle Volgian. Assemblage 2, dominated by *Haplophragmoides* in association with *Lenticulina*, represents a shallow, open marine environment and is confined to the upper part of Ratjønna Member of the Ryazanian. Assemblage 3, dominated by Nodosariidae and *Glomospira*, represents an open marine, neritic environment and is associated with the Nybrua Formation of Valanginian–Hauterivian age.

Species of *Haplophragmoides* in assemblages 1 and 2 of the Volgian–Ryazanian are poorly preserved and left under open nomenclature. However, these species are broadly comparable with forms reported from the Upper Jurassic–Lower Cretaceous of north-west Europe and the Arctic areas. Assemblage 3 shows close similarity to the Valanginian–Hauterivian microfaunas from north-west Europe. However, the dominance of calcareous species in assemblage 3 in Andøya and coeval beds in north-west Europe is in marked contrast to neritic faunas reported from Agardhfjellet, Spitsbergen, where Early Cretaceous microfaunas are dominated by simple arenaceous forms. These faunal differences are probably the result of substrate, latitudinal, or climatic factors.

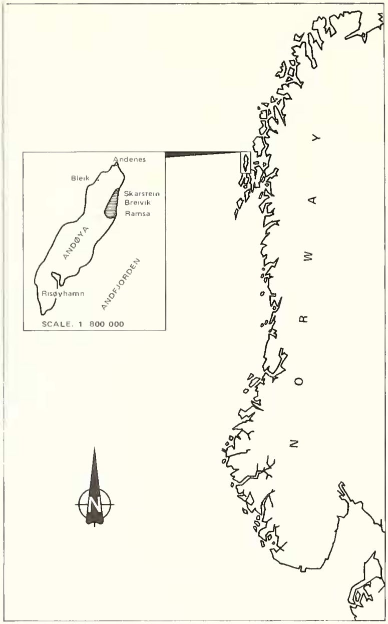
THE present investigation reports micropalaeontological analysis of surface and mechanically excavated sections of the Upper Jurassic (Volgian) to Lower Cretaceous (Hauterivian) sequence from Andøya, an island in the Vesterålen archipelago, in northern Norway (text-fig. 1). The Jurassic and Cretaceous sequence (text-fig. 2) consists predominantly of sandstones and shales resting unconformably on granitic Pre-Cambrian basement. For detailed account on sedimentology and biostratigraphy the reader is referred to Dalland (1975), Thusu and Vigran (1975), and Birkelund *et al.* (1978). In the present paper a complete list of foraminifera is given and an assessment of their biostratigraphic, palaeoecologic, and palaeobiogeographic significance is attempted.

Foraminifera were recovered by boiling the samples in a weak solution of NaOH for a short time before sieving in the usual manner.

STRATIGRAPHY

The Jurassic and Cretaceous sequence of Andøya is about 650 m thick (text-fig. 2) and consists predominantly of sandstones and shales deposited in two small troughs. The age of the sediments is Middle to Late Jurassic in the southern, and Early Cretaceous in the northern trough. The Jurassic includes the Ramså Formation and the bulk of the Dragneset Formation (text-fig. 2). The Ramså Formation consists of sandstones, shales, and coal layers that did not yield any microfauna. The overlying Dragneset

[Palaeontology, Vol. 22, Part 2, 1979, pp. 413–425, pls. 46–47.]



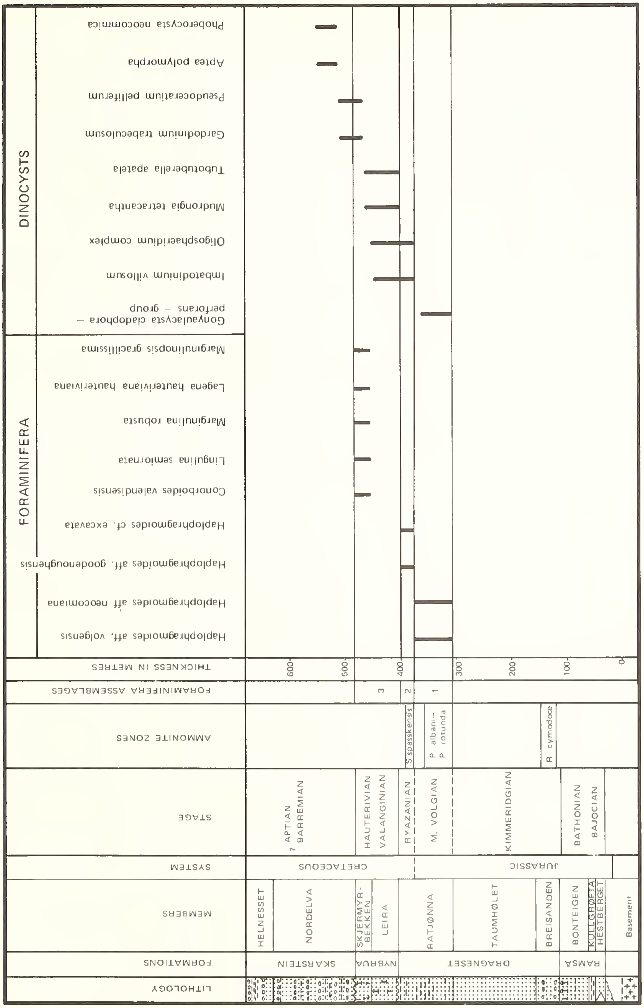
TEXT-FIG. 1. Location of study area.

Formation consists of three members, the youngest of which the Ratjønna Member, a predominantly silty shale unit of the Middle Volgian–Ryazanian age, contains agglutinated foraminifera. The Lower Cretaceous Nybrua Formation consists of calcareous sandstone, siltstone, and marl of Valanginian–Hauterivian age. The Leira and Skjærmyrbekken members of the Nybrua Formation contain abundant calcareous and agglutinated foraminifera. The two remaining units, Nordelva and Helinesset formations, consist of sandstone and shale that contain sparse microfaunas.

PALAEOENVIRONMENT

Three foraminiferal assemblages are recognized in the Dragneset and Nybrua formations (text-fig. 2). These assemblages and their age and environmental interpretations are summarized below.

Assemblage 1. This assemblage is restricted to the lower part of the Ratjønna Member (text-fig. 2), correlated with the *Pavlovia rotunda–Progalbanites* zones of the Middle



TEXT-FIG. 2. Selected foraminifera and dinocysts close to the Jurassic/Cretaceous boundary in Andøya, Norway.

Volgian. The assemblage is made up exclusively of poorly preserved arenaceous specimens of *Haplophragmoides*. Nearly 100% of the assemblage consists of *H.* aff. *neocomiana* (Chapman). Some of the individuals seem to be intermediate forms between *H. neocomiana* (Chapman) and *H. concava* (Chapman). Some individuals of *H.* aff. *volgensis* Myatliuk are also recorded in this assemblage. Although *H. neocomiana* is known to occur in the Lower Cretaceous of western Europe (Chapman 1894; Ten Dam 1948; Fletcher 1972) and *H. volgensis* in the Upper Jurassic of Poland and U.S.S.R. (Bielecka 1975), all the forms recorded here are left under open nomenclature because of the poor preservation.

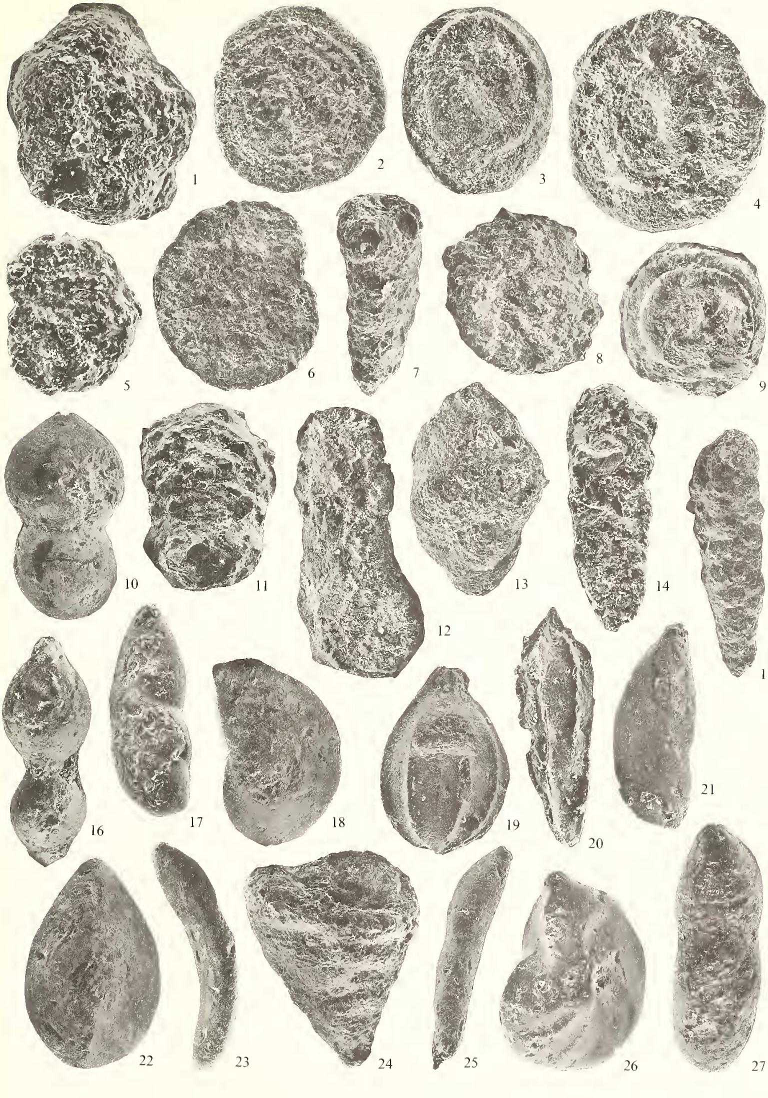
Species of *Haplophragmoides* are known to have wide environmental tolerances. Chamney (1977) considered this genus to reach its optimum support in the normal marine environment of the shelf-slope contact, at an approximate depth of 130 m. The incoming of dinocysts *Gonyaulacysta cladophora-perforans* group in abundance suggests a shallow marine environment. However, this poorly preserved, restricted arenaceous fauna also could be the result of reduced oxygen supply. This is supported by the presence of dark, laminated siltstones composing most of the Ratjønna

---

EXPLANATION OF PLATE 46

Taxa from assemblage 1, figures 1, 6; Volgian, Dragneset Formation, lower part of Ratjønna Member; assemblage 2, figures 5, 8; Ryazanian, Dragneset Formation, upper part of Ratjønna Member. All other taxa from assemblage 3, Valanginian–Hauterivian, Nybrua Formation, Leira Member, Andøya. All figures are side views.

Fig. 1. *Haplophragmoides* aff. *volgensis* Myatliuk, ×105.
Fig. 2. *Ammodiscus tenuissima* (Gümbel), ×140.
Fig. 3. *Glomospira gordialis* (Jones and Parker), ×130.
Fig. 4. *Glomospirella gaultina* (Berthelin), ×140.
Fig. 5. *Haplophragmoides* cf. *excavata* Cushman and Waters, ×65.
Fig. 6. *Haplophragmoides* aff. *neocomiana* (Chapman), ×65.
Fig. 7. *Verneuilinoides inaequalis* Bartenstein and Brand, ×80.
Fig. 8. *Haplophragmoides* aff. *goodenoughensis* Chamney, ×40.
Fig. 9. *Glomospira* cf. *charoides* (Jones and Parker), ×80.
Fig. 10. *Nodosaria loeblichae* Ten Dam, ×125.
Fig. 11. *Haplophragmium aequale* (Roemer), ×45.
Fig. 12. *Ammobaculites* cf. *subcretacea* Cushman and Alexander, ×70.
Fig. 13. *Uvigerinammina* sp., ×80.
Fig. 14. *Textularia foeda* Reuss, ×105.
Fig. 15. *Verneuilinoides* cf. *neocomiensis* (Myatliuk), ×50.
Fig. 16. *Nodosaria* cf. *regularis* Terquem, ×75.
Fig. 17. *Astacolus* cf. *cephalotes* (Reuss), ×85.
Fig. 18. *Lenticulina gaultina* (Berthelin), ×35.
Fig. 19. *Lagena sulcata* (Walker and Jacob), ×155.
Fig. 20. *Dentalina inepta* Reuss, ×110.
Fig. 21. *Astacolus* cf. *gratus* (Reuss), ×105.
Fig. 22. *Lenticulina* aff. *ovalis* (Reuss), ×80.
Fig. 23. *Dentalina linearis* (Roemer), ×85.
Fig. 24. *Dorothia* cf. *hechti* Dieni and Massari, ×95.
Fig. 25. *Dentalina* cf. *communis* d'Orbigny, ×35.
Fig. 26. *Lenticulina münsteri* (Roemer), ×75.
Fig. 27. *Dentalina cylindroides* Reuss, ×50.



LØFALDLI and THUSU, Norwegian Mesozoic Foraminifera

Member, which according to Dalland (1975) may have been deposited in somewhat deeper water with a deficiency of oxygen. The presence of coaly matter and also the absence of calcareous foraminifera, in contrast to assemblages 2 and 3 also might indicate somewhat restricted marginal marine environment for this assemblage.

Assemblage 2. This assemblage occurs in the upper part of the Ratjønna Member, correlated with the ammonite zone *Surites* (*Bojarkia*) *mesezhnikovi*, of the Ryazanian. The fauna consists of poorly preserved arenaceous forms and a few calcareous species. *H.* aff. *goodenoughensis* Chamney, *H.* cf. *excavata* Cushman and Waters appear together with species of *Bathysiphon*, *Reophax*, and *Lenticulina*. *H.* aff. *goodenoughensis* is the most common form in this assemblage and seems most similar to individuals recorded from the Lower Cretaceous of Arctic Canada (Chamney, 1969; Souaya, 1976) and Spitsbergen (Løfaldli, unpublished data). However, the forms recorded here are left under open nomenclature because of the poor preservation of the fauna.

The appearance of calcareous forms together with rich invertebrate faunas (Dalland 1975) and dinocysts (Birkelund *et al.* 1978) indicates a shallow, open marine environment for the assemblage.

EXPLANATION OF PLATE 47

All taxa from assemblage 3, Valanginian–Hauterivian, Nybrua Formation, Skjærmyrbekken Member, Andøya. Except where otherwise stated figures are side views.

Fig. 1. *Planularia* cf. *bradyana* (Chapman), ×85.
Fig. 2. *Dentalina nana* Reuss, ×35.
Fig. 3. *Pseudonodosaria mutabilis* (Reuss), ×75.
Fig. 4. *Pseudonodosaria humilis* (Roemer), ×135.
Fig. 5. *Lenticulina perobliqua* (Reuss), ×60.
Fig. 6. *Pseudonodosaria tenuis* (Bornemann), ×105.
Fig. 7. *Saracenaria frankei* Ten Dam, ×75.
Fig. 8. *Lenticulina* aff. *sigali* Bartenstein, Bettenstaedt and Bolli, ×70.
Fig. 9. *Marginulinopsis comma* (Roemer), ×55.
Fig. 10. *Marginulinopsis gracillissima* (Reuss), ×110.
Fig. 11. *Lingulina loryi* (Berthelin), ×110.
Fig. 12. *Globulina prisca* Reuss, ×115.
Fig. 13. *Quadrulina brunsviga* Zedler, ×140.
Fig. 14. *Oolina globosa* (Montagu), ×225.
Fig. 15. *Bullopora tuberculata* (Sollas), ×180.
Fig. 16. *Marginulina robusta* Reuss, ×120.
Fig. 17. *Sigmomorphina* aff. *neocomiensis* Sztejn, ×160.
Fig. 18. *Vaginulinopsis humilis praecursoria* Bartenstein and Brand, ×45.
Fig. 19. *Lamarckina lamplughi* (Sherlock), ventral view, ×185.
Fig. 20. *Lingulina semiornata* Reuss, ×115.
Fig. 21. *Rosalina nitens* Reuss, ventral view, ×145.
Fig. 22. *Ramulina aculeata* Wright, ×50.
Fig. 23. *Patellina subcretacea* Cushman and Alexander, dorsal view, ×145.
Fig. 24. *Lamarckina lamplughi* (Sherlock), dorsal view, ×185.
Fig. 25. *Conorboides valendisensis* (Bartenstein and Brand), dorsal view, ×140.
Fig. 26. *Rosalina nitens* Reuss, dorsal view, ×145.
Fig. 27. *Conorboides valendisensis* (Bartenstein and Brand), ventral view, ×155.

LØFALDLI and THUSU, Norwegian Mesozoic Foraminifera

Assemblage 3. The microfaunas in samples from the Nybrua Formation alternate from rich to very sparse, and are partly well-preserved. A mixed arenaceous–calcareous assemblage is recorded both in Leira and Skjærmyrbekken members. The characteristic of the calcareous fauna is displayed by the diversity of the Nodosariidae, of which *Lenticulina*, *Dentalina*, *Astacolus*, *Lagena*, *Marginulina*, and *Marginulinopsis* are best represented. The calcareous forms are represented by numerous species, although most of them are represented by fewer specimens. The most important index-fossils seem to be the following:

Conorboides valendisensis, recorded from Valanginian of western Germany (Kemper 1961) and in Berriasian–Valanginian of Yorkshire (Fletcher 1972).

Lamarckina lamplughi, recorded in Hauterivian to Albian of Europe (Bartenstein *et al.* 1971).

Vaginulina recta, known from Valanginian to Albian of Europe (Sztejn 1957).

Lenticulina wisselmanni, ranges from Hauterivian to Aptian in Germany and England (Khan 1962).

Lagena hauteriviana hauteriviana, known from Berriasian to Barremian in Germany (Michael 1967) and England (Fletcher 1972).

Marginulinopsis comma, previously recorded from Valanginian to Albian of the Netherlands and Germany (Ten Dam 1948).

Patellina subcretacea, recorded from Valanginian to Albian of Europe (Sztejn 1957).

Arenaceous foraminifera include *Glomospira*, *Glomospirella*, *Bathysiphon*, *Haplophragmium*, *Bigenerina*, *Uvigerinammina*, *Textularia*, *Ammobaculites*, *Ammodiscus*, *Verneuilinoides*, and *Reophax*. Of note is the presence of *Lenticulina* and *Glomospira* in large numbers. The commonest species are *Glomospira* cf. *charoides*, *G. gordialis*, *Haplophragmium aequale*, *Lenticulina* aff. *ovalis*, and *L. münsteri*. Such an assemblage is characteristic of open marine, neritic environment. This assemblage is most similar to those reported from the Valanginian–Hauterivian sediments of north-western Europe and Poland (Hecht 1938; Ten Dam 1946, 1948; Bartenstein 1956; Sztejn 1957; Bartenstein and Kaever 1973; Fletcher 1972).

Discussion. The great distances that isolate Late Jurassic and Early Cretaceous foraminiferal assemblages in Andøya from other reported assemblages of similar age render the island an important link for palaeobiogeographic reconstruction. In the Middle Volgian–Ryazanian times Andøya lay near the marginal areas of the northernmost Atlantic epicontinental sea which was connected to the north with the boreal sea of the Arctic region and to the boreal Atlantic Sea in the south-west. Species of *Haplophragmoides* in assemblages 1 and 2 of the Volgian–Ryazanian are poorly preserved and left under open nomenclature. However, these species are broadly comparable to forms reported from the Upper Jurassic–Lower Cretaceous of north-west Europe and the Arctic areas. In Valanginian–Hauterivian times a major transgression began as a result of Late Kimmerian phase of faulting. The influx of calcareous forms in assemblage 3 of Valanginian–Hauterivian age in the Nybrua Formation is probably the result of this transgression. Well over 90% of calcareous forms recorded in assemblage 3 are known to occur in coeval beds in north-west Europe. However, the dominance of calcareous forms in assemblage 3 in Andøya is in marked contrast to neritic faunas reported from Agardhfjellet, Spitsbergen where Early Cretaceous assemblages are dominated by simple arenaceous forms in which one or several species make up the bulk of the assemblage. Løfaldli and Thusu (1976, p. 76) conclude that these faunal differences are probably the result of sedimentary substrate, latitudinal, or climatic factors in Spitsbergen.

SYSTEMATIC ACCOUNT OF FORAMINIFERA

In this paper some seventy species of foraminifera are recorded. All of these are benthonic. More than 70% of the recorded species are calcareous, and the remaining arenaceous. Some of the difficulties concerns the poor state of preservation of the tests and the rare occurrences of most of the species. This explains the use of open nomenclature in many identifications. The literature that has mainly been used for the identifications are Hecht (1938), Ten Dam (1946, 1948), Bartenstein and Brand (1951), Bartenstein, Bettenstaedt, and Bolli (1957), Sztejn (1957), Bartenstein and Bettenstaedt (1962), Bartenstein and Kaever (1973), and Dailey (1973).

The families and genera of the foraminifera are arranged according to the classification of Loeblich and Tappan (1964).

Astrorhizidae
Bathysiphon spp.
Ammodiscidae
Ammodiscus tenuissima (Gümbel) = *Spirillina tenuissima* Gümbel, 1862. Plate 46, fig. 2
Glomospira cf. *charoides* (Jones and Parker) = *Trochammina squamata* var. *charoides* Jones and Parker, 1860. Plate 46, fig. 9
Glomospira gordialis (Jones and Parker) = *Trochammina squamata gordialis* Jones and Parker, 1860. Plate 46, fig. 3
Glomospirella gaultina (Berthelin) = *Ammodiscus gaultinus* Berthelin, 1880. Plate 46, fig. 4
Hormosinidae
Reophax spp.
Lituolidae
Haplophragmoides cf. *excavata* Cushman and Waters, 1927. Plate 46, fig. 5
Haplophragmoides aff. *goodenoughensis* Chamney, 1969. Plate 46, fig. 8
Haplophragmoides aff. *neocomiana* (Chapman) = *Haplophragmium neocomianum* Chapman, 1894. Plate 46, fig. 6
Haplophragmoides aff. *volgensis* Myatliuk, 1939. Plate 46, fig. 1
Ammobaculites cf. *subcretacea* Cushman and Alexander, 1930. Plate 46, fig. 12
Haplophragmium aequale (Roemer) = *Spirolina aequalis* Roemer, 1841. Plate 46, fig. 11
Textulariidae
Textularia foeda Reuss, 1846. Plate 46, fig. 14
Bigenerina sp.
Ataxophragmiidae
Uvigerinammina sp. Plate 46, fig. 13
Verneuilinoides inaequalis Bartenstein and Brand, 1951. Plate 46, fig. 7
Verneuilinoides cf. *neocomiensis* (Myatliuk) = *Verneuilina neocomiensis* Myatliuk, 1939. Plate 46, fig. 15
Dorothia cf. *hechti* Dieni and Massari, 1966. Plate 46, fig. 24
Nodosariidae
Nodosaria loeblichae Ten Dam, 1948. Plate 46, fig. 10
Nodosaria cf. *regularis* Terquem, 1862. Plate 46, fig. 16
Astacolus cf. *cephalotes* (Reuss) = *Cristellaria* (*Cristellaria*) *cephalotes* Reuss, 1863. Plate 46, fig. 17
Astacolus cf. *gratus* (Reuss) = *Cristellaria* (*Cristellaria*) *grata* Reuss, 1863. Plate 46, fig. 21
Astacolus scitula (Berthelin) = *Cristellaria scitula* Berthelin, 1880
Astacolus schlönbachi (Reuss) = *Cristellaria* (*Cristellaria*) *schlönbachi* Reuss, 1863

Dentalina cf. *communis* d'Orbigny, 1826. Plate 46, fig. 25
Dentalina cylindroides Reuss, 1860. Plate 46, fig. 27
Dentalina inepta Reuss, 1863. Plate 46, fig. 20
Dentalina linearis (Roemer) = *Nodosaria linearis* Roemer, 1841. Plate 46, fig. 23
Dentalina nana Reuss, 1863. Plate 47, fig. 2
Dentalina oligostegia (Reuss) = *Nodosaria oligostegia* Reuss, 1845
Frondicularia hastata Roemer, 1842
Lagena hauteriviana hauteriviana Bartenstein and Brand, 1951
Lagena sulcata Walker and Jacob = *Serpula* (*Lagena*) *sulcata* Walker and Jacob, 1798. Plate 46, fig. 19
Lenticulina gaultina (Berthelin) = *Cristellaria gaultina* Berthelin, 1880. Plate 46, fig. 18
Lenticulina incurvata (Reuss) = *Cristellaria incurvata* Reuss, 1863
Lenticulina münsteri (Roemer) = *Robulina münsteri* Roemer, 1839. Plate 46, fig. 26
Lenticulina aff. *ovalis* (Reuss) = *Cristellaria ovalis* Reuss, 1845. Plate 46, fig. 22
Lenticulina perobliqua (Reuss) = *Cristellaria* (*Cristellaria*) *perobliqua* Reuss, 1863. Plate 47, fig. 5
Lenticulina saxonica Bartenstein and Brand, 1951
Lenticulina aff. *sigali* Bartenstein, Bettenstaedt and Bolli = *Lenticulina* (*Marginulinopsis*) *sigali* Bartenstein, Bettenstaedt and Bolli, 1957. Plate 47, fig. 8
Lenticulina wisselmanni Bettenstaedt, 1952
Marginulina robusta Reuss = *Cristellaria* (*Marginulina*) *robusta* Reuss, 1862. Plate 47, fig. 16
Marginulinopsis comma (Roemer) = *Marginulina comma* Roemer, 1841. Plate 47, fig. 9
Marginulinopsis gracillissima (Reuss) = *Cristellaria gracillissima* Reuss, 1862. Plate 47, fig. 10
Planularia cf. *bradyana* (Chapman) = *Cristellaria bradyana* Chapman, 1894. Plate 47, fig. 1
Pseudonodosaria humilis (Roemer) = *Nodosaria humilis* Roemer, 1841. Plate 47, fig. 4
Pseudonodosaria mutabilis (Reuss) = *Glandulina mutabilis* Reuss, 1863. Plate 47, fig. 3
Pseudonodosaria tenuis (Bornemann) = *Glandulina tenuis* Bornemann, 1854. Plate 47, fig. 6
Saracenaria frankei Ten Dam, 1946. Plate 47, fig. 7
Saracenaria triangularis d'Orbigny, 1840
Vaginulina recta Reuss, 1863
Vaginulinopsis humilis praecursoria Bartenstein and Brand = *Lenticulina* (*Vaginulinopsis*) *humilis praecursoria* Bartenstein and Brand, 1951. Plate 47, fig. 18
Lingulina lamellata Tappan, 1940
Lingulina loryi (Berthelin) = *Frondicularia loryi* Berthelin, 1880. Plate 47, fig. 11
Lingulina semiornata Reuss, 1863. Plate 47, fig. 20
Polymorphinidae
Globulina prisca Reuss, 1863. Plate 47, fig. 12
Pyrulina infracretacea Bartenstein, 1952
Sigmomorphina aff. *neocomiensis* Sztejn, 1957. Plate 47, fig. 17
Quadrulina brunsviga Zedler, 1961. Plate 47, fig. 13
Bullopora tuberculata (Sollas) = *Webbina tuberculata* Sollas, 1877. Plate 47, fig. 15
Ramulina aculeata Wright, 1886. Plate 47, fig. 22
Glandulinidae
Tristix acutangulum (Reuss) = *Rhabdogonium acutangulum* Reuss, 1862
Oolina globosa (Montagu) = *Vermiculum globosum* Montagu, 1803. Plate 47, fig. 14
Discorbidae
Rosalina nitens Reuss, 1863. Plate 47, figs. 21, 26
Spirillinidae
Spirillina minima Schacko, 1892
Patellina subcretacea Cushman and Alexander, 1930. Plate 47, fig. 23
Involutinidae
Trocholina infragranulata Noth, 1951
Anomalinidae
Gavelinella sigmoicosta (Ten Dam) = *Anomalina sigmoicosta* Ten Dam, 1948
Ceratobuliminidae
Conorboides valendisensis (Bartenstein and Brand) = *Conorbis valendisensis* Bartenstein and Brand, 1951. Plate 47, figs. 25, 27
Lamarckina lamplughi (Sherlock) = *Pulvinulina lamplughi* Sherlock, 1914. Plate 47, figs. 19, 24

TABLE 1. Occurrence of foraminifera

(R = rare, C = common, A = abundant)

	Member		
	Ratjønna	Leira	Skjærmyrbekken
Ammobaculites cf. *subcretacea* (Pl. 46, fig. 12)		C	C
Ammodiscus tenuissima (Pl. 46, fig. 2)		R	R
Astacolus cf. *cephalotes* (Pl. 46, fig. 17)			C
A. cf. *gratus* (Pl. 46, fig. 21)			C
A. schlönbachi			C
A. scitula			C
Bathysiphon spp.	R	C	C
Bigenerina spp.		R	R
Bullopora tuberculata (Pl. 47, fig. 15)			R
Conorboides valendisensis (Pl. 47, figs. 25, 27)			R
Dentalina cf. *communis* (Pl. 46, fig. 25)			C
D. cylindroides (Pl. 46, fig. 27)			C
D. inepta (Pl. 46, fig. 20)			R
D. linearis (Pl. 46, fig. 23)			C
D. nana (Pl. 47, fig. 2)			C
D. cf. *oligostegia*			R
Dorothia cf. *hechti* (Pl. 46, fig. 24)			R
Frondicularia hastata			R
Gavelinella sigmoicosta			R
Globulina prisca (Pl. 47, fig. 12)			C
Glomospira cf. *charoides* (Pl. 46, fig. 9)		A	A
G. gordialis (Pl. 46, fig. 3)		A	A
Glomospirella gaultina (Pl. 46, fig. 4)		C	C
Haplophragmium aequale (Pl. 46, fig. 11)		C	C
Haplophragmoides cf. *excavata* (Pl. 46, fig. 5)	R		
H. aff. *goodenoughensis* (Pl. 46, fig. 8)	C		
H. aff. *neocomiana* (Pl. 46, fig. 6)	C		
H. aff. *volgensis* (Pl. 46, fig. 1)	R		
Lagena hauteriviana hauteriviana			R
L. sulcata (Pl. 46, fig. 19)		R	R
Lamarckina lamplughi (Pl. 47, figs. 19, 24)			R
Lenticulina gaultina (Pl. 46, fig. 18)			R
L. incurvata		R	R
L. münsteri (Pl. 46, fig. 26)	R	A	A
L. aff. *ovalis* (Pl. 46, fig. 22)		A	A
L. perobliqua (Pl. 47, fig. 5)		R	R
L. saxonica			R
L. aff. *sigali* (Pl. 47, fig. 8)			R
L. wisselmanni			R
Lingulina lamellata			R
L. loryi (Pl. 47, fig. 11)			R
L. semiornata (Pl. 47, fig. 20)			R
Marginulina robusta (Pl. 47, fig. 16)			R
Marginulinopsis comma (Pl. 47, fig. 9)			R
M. gracillissima (Pl. 47, fig. 10)			R
Nodosaria loeblichae (Pl. 46, fig. 10)			R
N. cf. *regularis* (Pl. 46, fig. 16)			R
Oolina globosa (Pl. 47, fig. 14)			R
Patellina subcretacea (Pl. 47, fig. 23)			R

	Member		
	Ratjønna	Leira	Skjærmyrbekken
Planularia cf. *bradyana* (Pl. 47, fig. 1)			R
Pseudonodosaria humilis (Pl. 47, fig. 4)			R
P. mutabilis (Pl. 47, fig. 3)			R
P. tenuis (Pl. 47, fig. 6)			R
Pyrulina infracretacea			R
Quadrulina brunsviga (Pl. 47, fig. 13)			R
Ramulina aculeata (Pl. 47, fig. 22)			R
Reophax spp.	R	R	R
Rosalina nitens (Pl. 47, figs. 21, 26)			R
Saracenaria frankei (Pl. 47, fig. 7)			R
S. triangularis			R
Sigmomorphina aff. *neocomiensis* (Pl. 47, fig. 17)			R
Spirillina minima			R
Textularia foeda (Pl. 46, fig. 14)		R	R
Tristix acutangulum			R
Trocholina infragranulata			R
Uvigerinammina sp. (Pl. 46, fig. 13)			C
Vaginulina recta			R
Vaginulinopsis humilis praecursoria (Pl. 47, fig. 18)			R
Verneuilinoides inaequalis (Pl. 46, fig. 7)			R
V. cf. *neocomiensis* (Pl. 46, fig. 15)			C

Acknowledgements. We wish to thank cand. real. Arne Dalland (University of Bergen) for providing samples and pertinent stratigraphic information, cand. real. Jenö Nagy (University of Oslo) for comments on the manuscript, engineer Kari Baardseth (Central Institute for Industrial Research, Oslo) for taking scanning micrographs, and Mr. Robin J. Godwin (Bristol University, U.K.) for photography.

REFERENCES

BARTENSTEIN, H. 1956. Zur Mikrofauna des Englischen Hauterive. *Senckenbergiana leth.* **37,** 509–533.

—— and BETTENSTAEDT, F. 1962. Marine Unterkreide (Boreal and Tehtys). In *Leitfossilien der Mikropaläontologie B7* (pp. 225–297). Arbeitskreis dtsch. Mikropaläont. Borntraeger, Berlin.

—— and BRAND, E. 1951. Micropaläontologische Untersuchungen zur Stratigraphie des norddeutschen Valendis. *Abh. senckenb. naturf. Ges.* **485,** 239–336.

—— and KAEVER, M. 1973. Die Unterkreide von Helgoland und ihre mikropaläontologische Gliederung. *Senckenbergiana leth.* **54,** 207–264.

—— BETTENSTAEDT, F. and BOLLI, H. M. 1957. Die Foraminiferen der Unterkreide von Trinidad. B.W.I. Erster Teil: Cuche- und Toco-Formation. *Eclogae geol. Helv.* **50,** 5–67.

—— —— and KOVATCHEVA, T. 1971. Foraminiferen des bulgarischen Barrême. *Neues Jahrb. f. Geol. u. Paläontologie*, Abh. **139,** 125–162.

BIELECKA, W. 1975. Foraminifera and brackish Ostracoda from the Portlandian of Polish Lowlands. *Acta Palaeont. Pol.* **20,** 295–393.

BIRKELUND, T., THUSU, B. and VIGRAN, J. 1978. Jurassic and Cretaceous biostratigraphy of North Norway with comments on British ammonite *Rasenia evoluta. Palaeontology*, **21,** 31–63.

CHAMNEY, T. P. 1969. Barremian Textulariina, Foraminiferida, from Lower Cretaceous beds, Mount Goodenough section, Aklavik Range, District of Mackenzie. *Bull. Canada Geol. Survey*, **185,** 1–41.

—— 1977. Foraminiferal morphogroup symbol for paleoenvironmental interpretation of drill cutting samples: Arctic America. Ist. Int. Symp. on Benthonic Foraminifera of Continental Margins. Part B. Paleoecology and Biostratigraphy. *Maritime Sediments Spec. Pub.* **1,** 585–624.

CHAPMAN, F. 1894. Bargate beds of Surrey and their microscopic contents. *Quart. Jour. Geol. Soc.* **50,** 677–730.

DAILEY, D. H. 1973. Early Cretaceous foraminifera from the Budden Canyon Formation, northwestern Sacramento Valley, California. *Univ. Calif. Publ. Geol. Sci.* **106,** 111 pp.

DALLAND, A. 1975. The Mesozoic rocks of Andøy, Northern Norway. *Norges Geol. Unders.* **316,** 271–287.

FLETCHER, B. N. 1972. The distribution of Lower Cretaceous (Berriasian–Barremian) foraminifera in the Speeton Clay of Yorkshire, England. *In* CASEY, R. and RAWSON, P. F. (eds.). *The Boreal Lower Cretaceous*, 161–168. Seal House Press, Liverpool.

HECHT, F. E. 1938. Standard-Gliederung der Nordwest-deutschen Unterkreide nach Foraminiferen. *Abh. senckenb. naturf. Ges.* **443,** 42 pp.

KEMPER, E. 1961. Mikrofauna und Faziesfossilien im unteren Mittelvalendis Nordwestdeutschlands. *Neues Jahrb. f. Geol. u. Paläontologie*, Monatshefte, 87–94.

KHAN, M. H. 1962. Lower Cretaceous index foraminifera from northwestern Germany and England. *Micropaleontology*, **8,** 385–390.

LOEBLICH, A. R. and TAPPAN, H. 1964. Sarcodina, chiefly 'Thecamoebians' and Foraminiferida. *In* MOORE, R. C. (ed.). *Treatise on Invertebrate Paleontology*, Part C, Protista 2. I–II. *Geol. Soc. Amer. and Univ. Kansas Press*, 900 pp.

LØFALDLI, M. and THUSU, B. 1976. Microfossils from the Janusfjellet Subgroup (Jurassic–Lower Cretaceous) at Agardhfjellet and Keilhaufjellet, Spitsbergen. *Norsk Polarinstitutt Årbok 1975*, 69–77.

MICHAEL, E. 1967. Die Mikrofauna des nw-deutschen Barrême. Teil I: Die Foraminiferen des nw-deutschen Barrême. *Palaeontographica Suppl.* **12,** 176 pp. Stuttgart.

SOUAYA, F. J. 1976. Foraminifera of Sun-Gulf-Global Linckens Island Well P-46, Arctic Archipelago, Canada. *Micropaleontology*, **22,** 249–306.

SZTEJN, J. 1957. Micropaleontological stratigraphy of the Lower Cretaceous in central Poland. *Inst. Geol. Prace*, **22,** 185–263.

TEN DAM, A. 1946. Arenaceous Foraminifera and Lagenidae from the Neocomian (Lower Cretaceous) of the Netherlands. *J. Paleont.* **20,** 570–577.

—— 1948. Foraminifera from the Middle Neocomian of the Netherlands. Ibid. **22,** 175–192.

THUSU, B. and VIGRAN, J. 1975. A review of the palynostratigraphy of the Jurassic system in Norway. 16 pp. In *NPF—Jurassic Northern North Sea Symposium*. Stavanger, 1975.

M. LØFALDLI

Continental Shelf Institute
Håkon Magūssons gt. 18
P.O. Box 1883
7001 Trondheim
Norway

B. THUSU

Arabian Gulf Exploration
P.O. Box 263
Benghazi
Libya

Typescript received 24 April 1978
Revised typescript received 11 September 1978